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APPENDICES A-F

APPENDIX A: TECHNICAL COMMITTEE STUDY ELEMENTS

Effects of Existing and Potential Changes in Water Use and Management

1. SNAKE RIVER WITHIN WATER DISTRICT 01

A. Review IDWR/UI GW Model Inputs. Prepare GIS data layers showing irrigated acres, by surface and sprinkler, in Non-Trust area.

B. Generate Base Study - Provide to Idaho Technical Committee on Hydrology (ITCH) for Review and Comment

C. Model Run with GW in Trust and Non-Trust areas deleted. Compare river gains and losses in Shelley to Blackfoot reach and Blackfoot to Milner reach to Baseline conditions. Compute effects on natural flows under equilibrium conditions.

D. Model run with changes from gravity to sprinkler of surface irrigated lands in the Trust and Non-Trust area deleted. Show changes in GIS data layer. Compare river gains and losses in Shelley to Blackfoot reach and Blackfoot to Milner reach to Baseline conditions. Compute effect on natural flows under equilibrium conditions. **Model run with surface water diversion rates at mid-1970's levels to show the effect of efficiency improvements which have been accomplished since that time. Compare river gains/losses to those under 1989 base conditions.**

E. Model run with potential new development in Non-Trust area added. Show additions in GIS data layer for surface and groundwater use. Compare river gains and losses in Shelley to Blackfoot reach and Blackfoot to Milner reach to baseline conditions. Compute effect on natural flows under equilibrium conditions.

F. Review the line of separation of ground water between trust and non-trust areas based on data collected since the original line was drawn.

G. Generate Time-Response curves for all model runs. Estimate the percent toward equilibrium under present conditions.

H. Estimate an effect on natural flow deliveries to TF&NS Canal Companies and others due to existing ground water use in the non-trust area.

I. Review and evaluate the procedures and data used to calculate the natural flow rights for the TF&NS Canal Companies. Prepare a report which describes the procedures.

J. Set up a system for use by Water District 01 in accounting for effect of GW use in Non-Trust area on natural flow rights of TF& NS Canal Companies and others. Formulate plan for GW users in Non-Trust area to compensate TF&NS Canal Companies using conjunctive management.

K. TOTAL STUDY COST FOR SNAKE RIVER WITHIN WATER DISTRICT 01 STUDY ELEMENT IS ESTIMATE TO BE ABOUT $97,000.

2. MAJOR TRIBUTARIES WITHIN WATER DISTRICT 01

L. Identify major tributary areas where surface water users may be significantly affected by ground water uses. Prepare a Plan of Study showing cost and issues for each potential study area.

M. THE ESTIMATED TOTAL COST FOR <u>IDENTIFYING</u> THE NUMBER OF STUDY AREAS AND PREPARING THE PLAN OF STUDY FOR EACH OF THE STUDY AREAS IS ESTIMATED TO BE $20,000.

3. SNAKE PLAIN AQUIFER

N. Prepare GIS data layers which identify ground water and surface water use under Baseline conditions. Compare to adjudication claims data to identify potential data problems.

O. Evaluate impacts of model studies with all groundwater irrigation on Snake River Plain deleted. Show this using GIS data layer. Compare river gains and losses throughout the system to Baseline conditions.

P. Model run to evaluate possible future changes from gravity to sprinkler of surface irrigated lands in the Trust and Non-Trust area deleted. Show changes in GIS data layer. Compare river gains and losses to Baseline conditions.

Q. Evaluate impacts of model studies with all changes in surface irrigation from gravity to sprinkler deleted. Show this using GIS data layer. Compare river gains and losses throughout system to Baseline conditions.

R. Run GW Model with potential new irrigation on Snake Plain Aquifer. Show this using GIS data layer. Compare river gains and losses throughout system to Baseline conditions.

S. Incorporate additions GW Model runs for alternatives identified through the IWRB study process. Prepare report on the hydrologic, economic, and environmental impacts of the different alternatives.

T. TOTAL STUDY COST FOR THE SNAKE PLAIN AQUIFER STUDY ELEMENT IS ESTIMATED TO BE ABOUT $125,000.

4. ENVIRONMENTAL CONCERNS

U. Cooperate with IWRB Middle Snake Study, IWRB Snake Plain Aquifer Study, US F&WL Service Endangered Species Studies, and DEQ Water Quality Studies in evaluating alternatives effecting the management and use of Snake River and spring flows for improving water quality and other environmental values.

V. ESTIMATED TOTAL COST FOR ADDRESSING ENVIRONMENTAL CONCERNS IS ABOUT $35,000

5. ARTIFICIAL RECHARGE

W. Review/evaluate data and information on recharge projects and prepare Plan of Study for a Recharge Project.

X. ESTIMATED TOTAL COST FOR ADDRESSING ARTIFICIAL RECHARGE IS $10,000

APPENDIX B: IDWR/UI ESPA GROUND WATER FLOW MODEL - GENERAL OUTLINE

CALCULATION PROCEDURE

Two dimensional
Block-centered, finite-difference
Iterative alternating direction-backward difference equation
Cartesian coordinate system-rectangular fixed grid
Selectable timestep
Leakage from overlying or to underlying water-bearing unit

CAPABILITIES

Steady state or transient(changes in head and flow with time)
Confined or unconfined aquifer or combinations
Model boundaries-fixed-head or fixed flux
Fixed head-time and location variable
Hydraulically connected rivers or drains
Fixed flux-underflow or zero-flux(impermeable)

PARAMETER ESTIMATION

Automatic on hydraulic conductivity, storage coefficient, leakance
Comparison of simulated to measured heads at each cell
Iterative procedure based on estimates of initial parameter(s) to be calibrated
Least-squares best-fit routine to minimize total sum of squares of differences between simulated and reference head values at each cell for each reference timestep
One parameter adjusted at a time
Parameter adjustments controlled by dampening factors

GROUND WATER MODEL INPUT

Grid parameters (interval, rows, columns)
Output specifications
Type of simulation
Type of aquifer system, timestep data

Calibration parameters, output mode
Reference timestep designations
Parameter calibration limits
River reach and cell groups (drains, rivers)
Initial parameters for each cell (K, leakance, S)
Cell type identifiers (outside, fixed head, basic node, fixed flux, confined, thickness, land surface elevation, aquifer bottom elevation, initial potentiometric surface)

RECHARGE PROGRAM

Data management routines to generate ground water model flux for each cell for each timestep

1. Seepage from canals
2. Recharge from surface water supplied irrigation
3. Pumping for irrigation or other (based on vegetation ET and soil moisture retention or supplied)
4. Recharge from precipitation
5. Gains and losses from rivers or lakes
6. Underflow across model boundaries

Recharge (+) or discharge (-) from each node is calculated as the residual in the water balance for each node for each timestep. The equation is:

$$Q = SEEP + (irr + rain - ET - soil) + WELL + RIVER + UNDER$$

SEEP	=	canal seepage
irr	=	surface water irrigation
rain	=	effective precipitation
soil	=	change in soil water content
WELL	=	pumping withdrawals
RIVER	=	river gains or losses
UNDER	=	ground-water underflow

Canal seepage is based on canal wetted area per node and seepage rate based on soil type or measured data. Each canal in each node is coded to a specific irrigation district or canal company which diverts from the river or stream and either serves lands in the cell or passes through the cell.

Canal seepage can either be calculated separately or lumped with surface irrigation water. Canal seepage can be changed during a simulation to represent changes in operation or canal lining.

The diversions and river return flows are coded by irrigation district or canal company and recorded diversions per time step input to an array. Recharge occurs only when irrigation application plus effective precipitation exceeds ET plus soil moisture storage. Irrigated areas for ground-water and surface water are delineated in each cell. The modeled area is divided into climatic zones in which crop ET, precipitation, and irrigation management are assumed to be similar. ET is calculated as the product of a reference crop ET and a crop coefficient which is time dependent.

Recharge on non-irrigated areas is calculated using a water balance similar to the irrigated areas except that ET is different and no irrigation water is applied.

Ground water pumping is normally calculated as the crop consumptive use for the ground water irrigated area in each cell. Any pumping in excess of ET is assumed to return to the aquifer in the same timestep as the pumping occurred.

Effective precipitation is defined as that percentage of measured precipitation and/or snow melt which reaches the aquifer through deep percolation. Effective precipitation in climatic zones is defined in the program.

Extraction (pumping) from any aquifer can be specified by well. Normally, this routine is used to designate well pumping for other than irrigation or where the withdrawal is from a confined system where excess pumping for irrigation does not recharge the aquifer.

River gains and losses (fixed) are input by timestep for cells or groups of cells. This is normally based on historically measured reach gains. Underflow from tributary valleys is handled in the same way by distributing calculated ground water underflow over a group of cells.

LIMITATIONS AND ASSUMPTIONS

The program, although general, is limited by physical conditions and assumptions. A list of the major limitations and assumptions follows.

1. Recharge occurs in the same timestep as application, that is, no time is provided for movement through the unsaturated zone.
2. No significant lateral flow occurs above the water table in the unsaturated region.
3. The aquifer is unconfined (unless inputs are adjusted accordingly).
4. Ground-water irrigation occurs at rates sufficient to meet crop demands.
5. Ground-water irrigation occurs only between the dates specified by the user.
6. Irrigation supplies sufficient water to allow crops to transpire at their potential.
7. Irrigation application rates within a project are uniform.
8. Weather, agricultural practices, and soil properties are constant within a climatic region.
9 No significant amount of crops other than alfalfa, winter and spring grain, sugar beets, beans, peas, corn, potatoes, or pasture is grown.
10. The crop coefficients determined at Kimberly, Idaho are representative of the study area.
11. Evapotranspiration from alfalfa is proportional to yield.

12. The length of a timestep is neither too long nor too short to cause errors in the calculation of ET, according to the criteria described in "Algorithm Description."
13. Precipitation does not result in runoff.
14. River or creek gains or losses are uniform along a specified reach.
15. Underflow is uniform along a specified reach.

Deviations from the above assumptions require appropriate changes within the program.

APPENDIX C: ESPA MODELED AREA IRRIGATED ACREAGE

The ground water model studies completed for this investigation are based on estimates of irrigated acreage overlying the ESPA. Irrigated acreage is used in the water balance of the aquifer system to compute, 1) the location and volume of water lost from evapotranspiration (a discharge term) overlying areas irrigated from ground water pumping, and 2) the location and volume of excess seepage (a recharge term) overlying areas irrigated from surface sources. Accurate estimates of surface and ground water irrigated areas for both model calibration and present (base study) conditions are necessary for accurate study results. Described in this appendix are the methods used to arrive at these estimates for 1980 irrigated acres, which was used to calibrate the model, and for 1992 irrigated acres, which was used to complete the base study and all "what if " studies.

1980 IRRIGATED ACREAGE

The layer of irrigated acreage for 1980 was generated as part of a cooperative project with the USGS. This project is documented in detail in USGS Professional Paper 1408-E, "Water Use on the Snake River Plain, Idaho and Eastern Oregon"(Goodell, 198?).

The acreage was generated by computer processing Landsat MSS data covering the Eastern Snake Plain. The method used is described in an IDWR report, "1980 Inventory of Irrigated Cropland on the Snake River Plain" (Anderson, 198?). The report states that "A stratified random sampling design was used to insure representative data for the entire study area. Training statistics for land-cover classification were developed using a maximum-likelihood classifier in a modified clustering approach. A simple linear regression was conducted to determine the relationship of Landsat data to ground data." The regression relationship was used to correct Landsat acreage values based on the ground measured acreage by stratum.

1992 IRRIGATED ACREAGE

The layer of 1992 irrigated acreage for the modeled area was generated from two sources. The majority of the layer came from cooperative mapping done by IDWR and the USBR in 1990 through 1992. Three small areas (<10 square miles) were taken from a 1987 classification of Landsat satellite data. A description of the Landsat classification is found in the article, "Using Remote Sensing and GIS Technology to Help Adjudicate Idaho Water Rights" (March, 1990).

In 1990, personnel from the USBR began mapping irrigated agriculture on the Eastern Snake Plain. The project was designed specifically to map the method of irrigation: sprinkler or flood. The method involved using aerial photography taken in 1987 to map irrigated fields. The 1987 data were verified and updated by field checks in 1991-1992. The photography was 1:40,000-scale color infrared. The method was as follows: 1) reduce 1:24,000-scale quadrangle maps to 1:40,000; 2) overlay the quad maps on the photography and locally register the map to the image; 3) trace field boundaries and label fields as irrigated (by sprinkler or flood) or non-irrigated; and 4) field check the boundaries and labels. The 1992 final irrigated lands over the ESPA is shown by Figure C1.

GROUND AND SURFACE WATER IRRIGATED ACRES DISTRIBUTION

The acres identified by the USBR were then categorized as ground water or surface water irrigated. Accurate determination of water source is important in studies which involve assessing the impact on the aquifer and spring discharges of ground water pumping. Estimating changes the historical pattern of ground water development is accomplished by removing these acres and their consumptive use in the model.

For each one mile section inside the ESPA model where irrigated acres were identified, the IDWR water rights data base was overlaid and a ratio of surface water right acreage to ground water right acreage developed for each section. The mapped acres were proportioned in each section to ground and surface water irrigated based on the computed ratio. The acres were summed by model node as surface water acres or ground water acres. The surface water acres were then assigned to service areas so that they could be related to measured canal diversions delivered to that service area. Figures C2 and C3 show the proportional distribution of surface and ground water acres by model cell for 1980 and 1992, respectively.

Table C1 includes acreage summaries for the 1980 and 1992 irrigated acres used in the ESPA model. Ground water and surface water acres were adjusted to account for non-irrigated portions of the identified acres (farmstead, roads, infrastructure).

APPENDIX C REFERENCES

Anderson, H.N., 1983, 1980 Inventory of Irrigated cropland on the Snake River Plain, Unpublished Report, Idaho Image Analysis facility of the Idaho Department of Water Resources, 31 p.

Goodell, S.A., 1988, Water Use on the Snake River Plain, Idaho and Eastern Oregon: U.S. Geological Survey Professional Paper 1408-E, 51p.

Table C1. Surface and Ground Water Irrigated Acres Over Modeled Area of the ESPA

Year	Ground Water Acres	Surface Water Acres	Total Acres	Adjusted Groundwater Acres[1]	Adjusted Surface Water Acres[2]	Adjusted Total Acres
1980	793,184	915,615	1,708,799	753,524	778,272	1,531,797
1992	860,920	718,926	1,579,846	817,874	611,087	1,428,961

[1] Multiply by 0.95 to adjust ground water acres for non-irrigated portions

[2] Multiply by 0.85 to adjust surface water acres for non irrigated portions

Figure C1

Eastern Snake Plain Aquifer Irrigated Lands from the 1992 USBR Classification

Upper Snake Model

Eastern Snake Plain Aquifer

Irrigated Lands

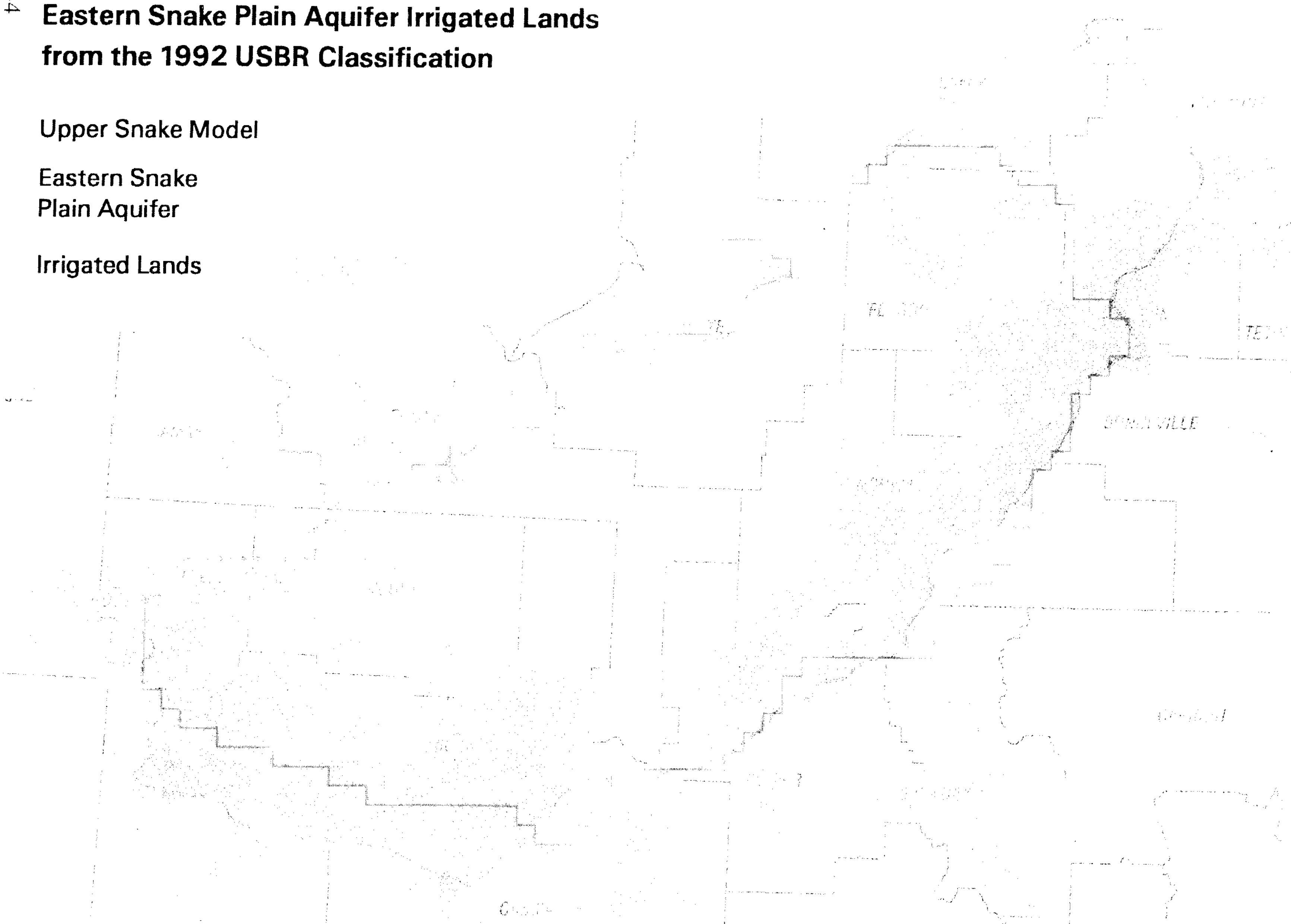


Figure C2

ESPA Ground Water Model: Proportion of Irrigation Source by Model Cell (1980)

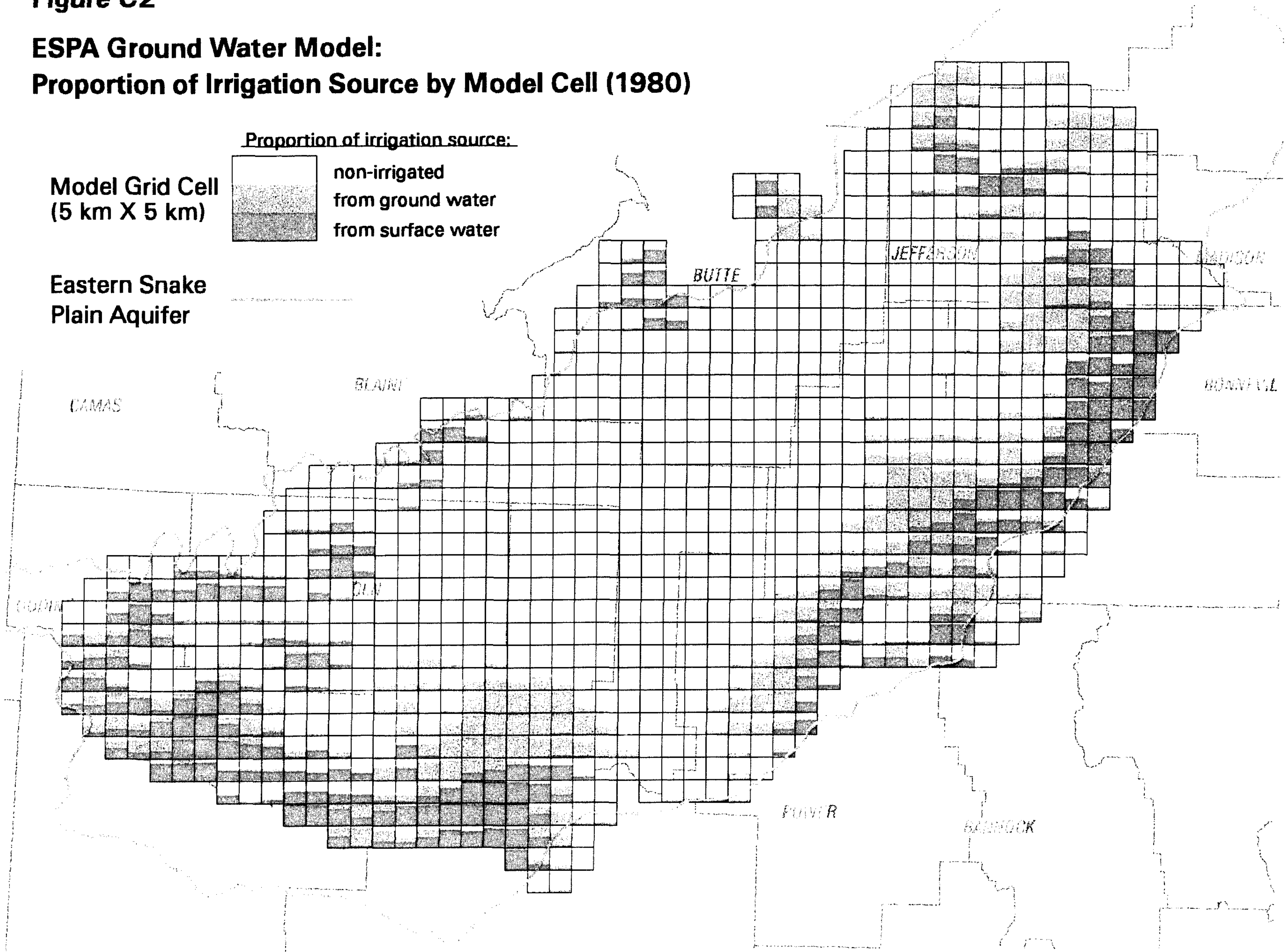
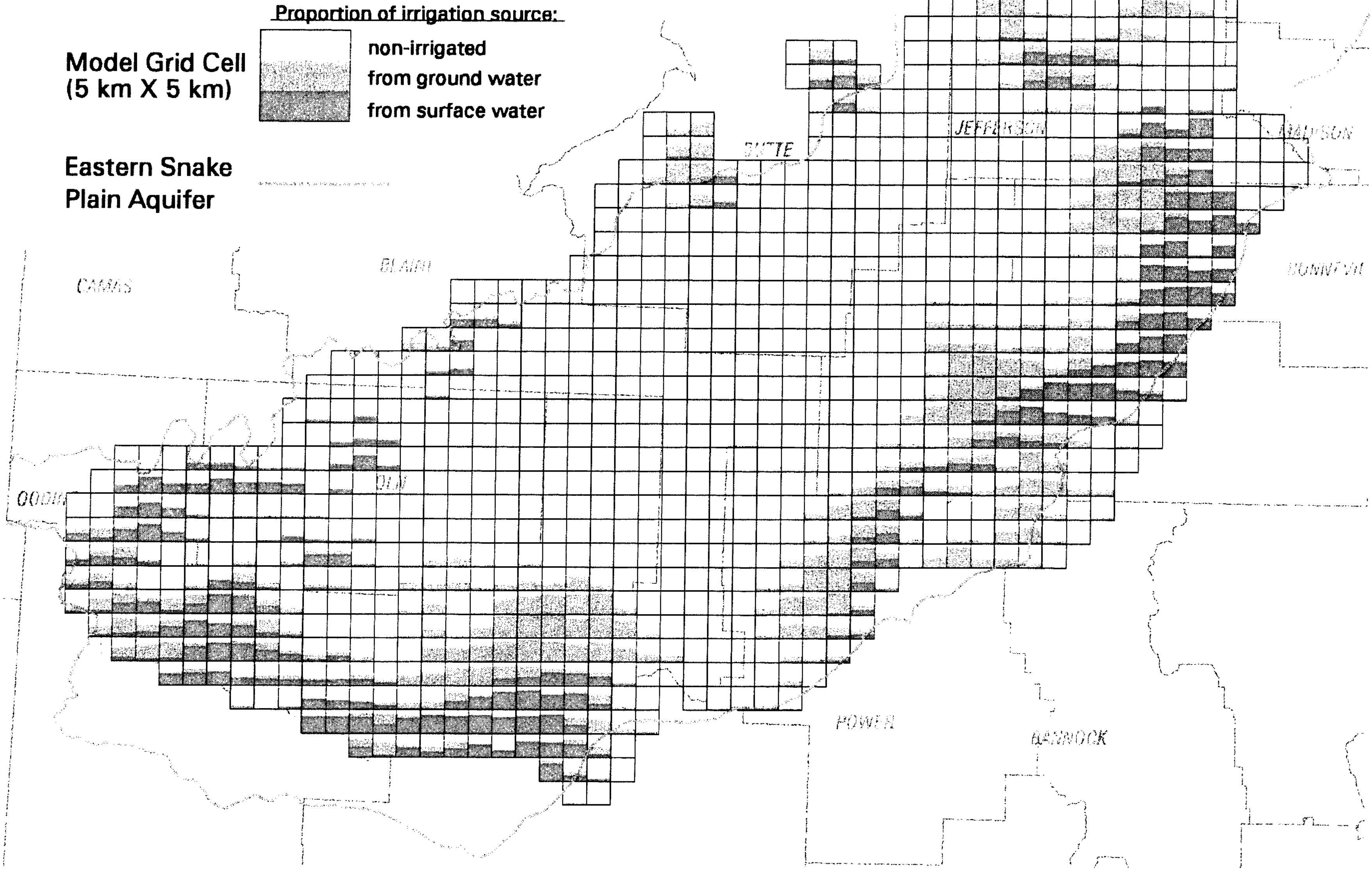


Figure C3

ESPA Ground Water Model:

Proportion of Irrigation Source by Model Cell (1992)



APPENDIX D. ESPA RECHARGE FROM THE HENRYS FORK AQUIFER

The ESPA receives substantial recharge (leakage) from the perched aquifer system overlaying the ESPA in the Henrys Fork and Rigby Fan area. The ESPA ground water model developed by IDWR and UI originally accounted for leakage from the Henrys Fork/Rigby Fan Aquifer (HFA) by adding a predetermined input value for each timestep for each underlying node. These values, which remained constant for each cycle (year), were estimated from a separate ground water flow model developed by UI (Wytzes, 1980 and Johnson, et al., 1985) for the HFA system. The HFA model accounts for leakage between the systems by assuming a constant ESPA head. The HFA modeled area and its overlap with the ESPA model is shown in Figure D1.

Actual leakage from the HFA to the ESPA is dependent on hydraulic heads in both aquifers. An increase in ESPA heads reduces the leakage from the HFA, and conversely, a decrease in ESPA heads increases the leakage from the HFA. However, due to the method of inputting the constant HFA leakage into the ESPA model impact of varying heads could not be simulated. A method was needed to simulate the leakage between the two aquifers under varying head differences when simulating a "what if" condition on the ESPA.

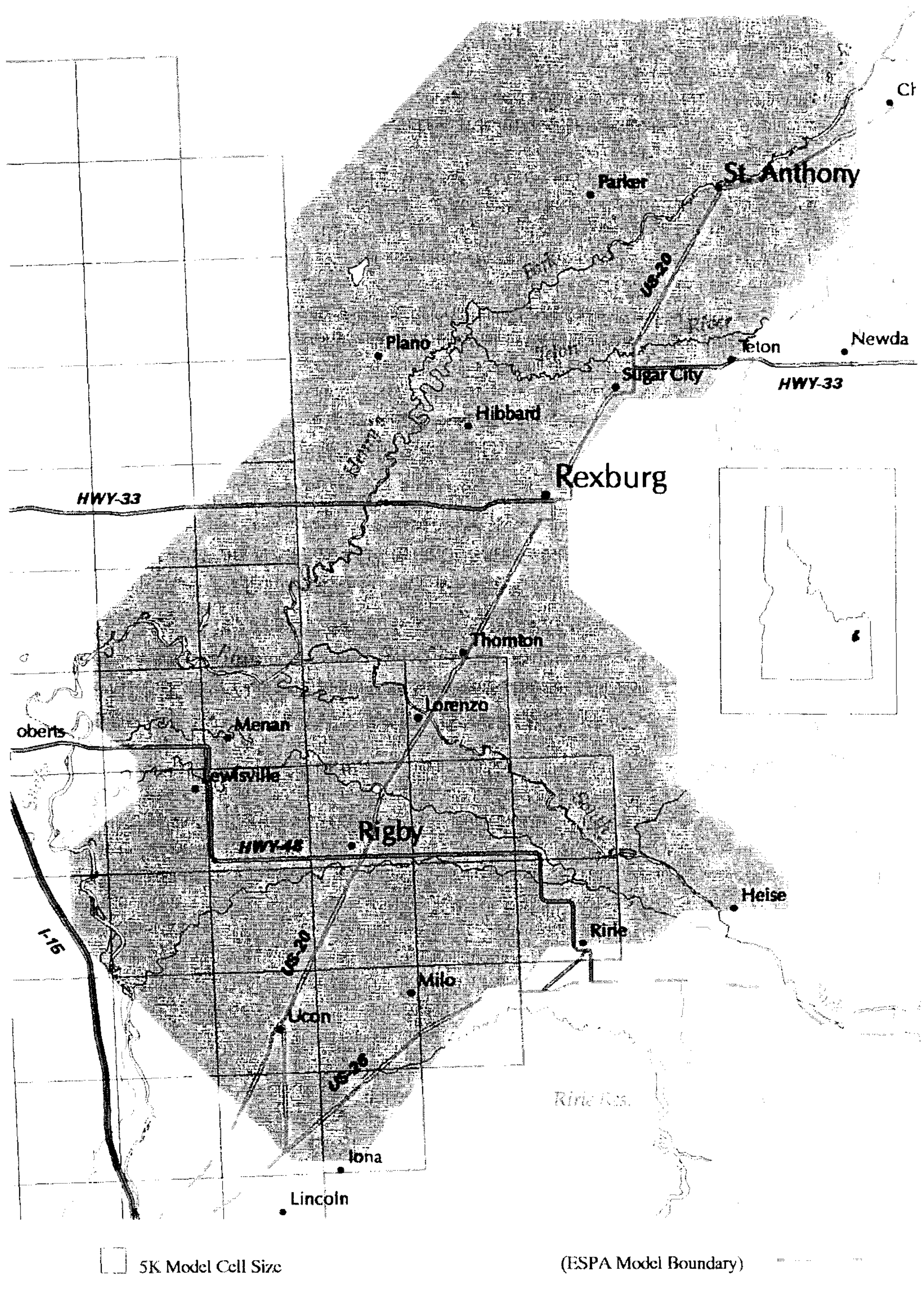
The ESPA model was modified to allow for head dependent leakage by using the HFA model to compute leakage over a range of head differences. Relationships between leakage and head differences were then developed.

PROCEDURE

The ESPA model was modified to incorporate head dependent leakage input values from the HFA by individual node or groups of nodes. Analysis of the change in leakage from the HFA (perched) system due to head changes in the ESPA (regional) system indicated that as the regional heads decreased the leakage would increase until the regional heads were below the aquitard separating the aquifers. Once the regional heads decreased below that level, the leakage would be a function of only the perched system heads regardless of the regional head. With regional heads above the aquitard separating the aquifers, the leakage from the perched system would be inversely proportional to the regional heads. When the regional heads exceed the perched system heads, the direction of flow between systems changes from recharge of the regional system to discharge from the regional system.

Figure D2 illustrates the functional relationship between leakage and regional system piezometric heads at each node. The portion of the relationship for regional heads above the aquitard should be linear; however, realizing that spatial effects (neighboring nodes) might induce non-linearity, the head dependent relationship incorporated into the ESPA model became non-linear with a lower limit corresponding to the point where the regional system drops below the aquitard.

Figure D1. Henry's Fork - Rigby Fan Model Area



5K Model Cell Size (ESPA Model Boundary)

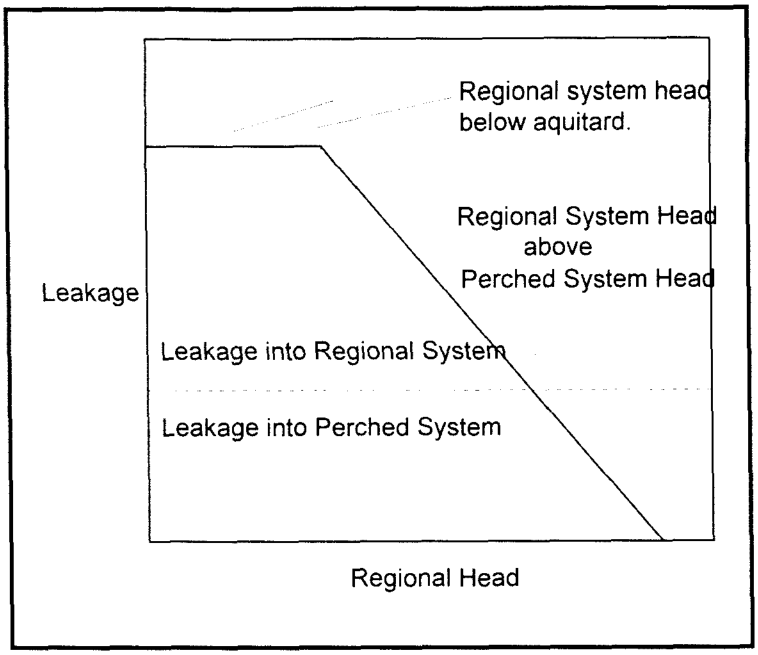


Figure D2. Leakage as a Function of Regional Heads

To develop the head to leakage relationship between the HFA and the ESPA, ten simulations were made utilizing a range of head differentials for 30 year periods. Johnson's single year calibration data set was extended to cover the 30 year period with bimonthly time steps. Changes in head differentials were applied uniformly across the HFA. The only exception was that the head differential was not changed when it resulted in a regional head below the bottom of the HFA system. For each of the last twenty-four time steps, the simulated leakage by node was extracted to develop relationships between leakage and head differential. Utilizing year thirty leakage data set, a relationship was developed for each time step of each node relating change in leakage to change in ESPA piezometric heads. Table D1 summarizes the combined change in leakage from all nodes for the ten simulation runs for year thirty. Figure D3 displays the relationship between ESPA change in head and annual leakage.

Table D1. HFA Leakage Response to ESPA Head Change

Assumed ESP Piezometric Head Change (ft)	Change in Head Differential (ft)	Average Change in Head Differential (ft)	Annual Leakage (kaf)	Change in Annual Leakage (kaf)
+30	-30	-30	1,095	-477
+25	-25	-25	1,178	-394
+20	-20	-20	1,260	-312
+15	-15	-15	1,339	-232
+10	-10	-10	1,418	-154
+5	-5	-5	1,496	-76
0	0	0	1,572	0
-5	+5	+5	1,647	+75
-10	+10	+7.8	1,721	+149
-15	+15		1,793	+221

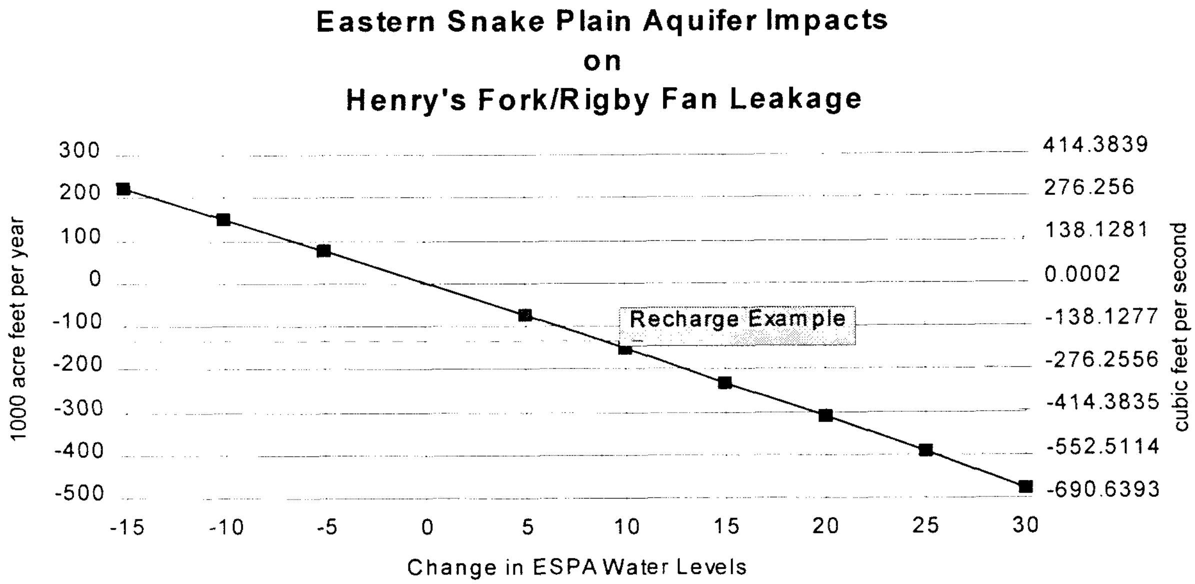


Figure D3. Change in HFA Leakage Due to ESPA Head Changes

The modified leakage from the HFA system results in potential changes in flows through hydraulically connected rivers and boundaries within the HFA modeled area. These locations are the Henrys Fork, Snake River and the Mud Lake area. Further examination of these showed change in surface discharge to the Mud Lake area to be insignificant. Therefore, flow changes were assumed to occur completely within the Henrys Fork and Snake River.

APPLICATION TO ESPA MODEL

The ESPA modeled area underlies only a portion of the HFA model (see Figure D1) Approximately 23 active ESPA nodes underlie the HFA model area. The HFA area overlies 35 non-active ESPA nodes. The base ESPA model's surface recharge term includes the leakage from the HFA distributed over the 23 active nodes with seven boundary nodes receiving the leakage associated with non-active nodes. On the basis of the original leakage distribution and similar heads, the 23 nodes were divided into 17 groups. For each group, the time step leakage coefficients were transformed to yield change in leakage as a function of absolute head instead of change in head.

Utilizing these 408 sets of equation coefficients, plus an additional 168 sets for boundary nodes, the ESPA model was modified to estimate change in recharge due to HFA leakage. To verify the accuracy of this method, a new base study simulation was made using the equation coefficient data sets. When compared to the original base study, no significant change in the computed HFA leakage occurred.

APPENDIX D REFERENCES

Johnson, G.S., C.D. Brockway, and S.P. Luttrell, 1985, Ground Water Model Calibration for the Henrys Fork Recharge Area: Idaho Water Resources Research Institute, University of Idaho, 18p.

Wytzes, J., 1980, Development of a Ground Water Model for the Henrys Fork and Rigby Fan area, Upper Snake River Basin: Idaho Water and Energy Resources Research Institute, University of Idaho, Moscow, Idaho, 205p.

APPENDIX E: MAJOR FEATURES OF IDWR WATER DISTRICT 1 WATER RIGHT ACCOUNTING PROCEDURE

1. Gains are computed to the river by reaches. There are 26 reaches in Water District 1 which are defined by stream gages. For each reach, gain is the sum of outflow plus diversions minus inflow. If there is a reservoir in the reach, the change in storage is added. Evaporation from the reservoir is also added unless it is a natural lake. Return flow from irrigation which may enter the river in the reach is not deducted from the gain because, for water distribution purposes, it is allocated as natural flow.

2. Natural flow in each reach is the sum of gains from the headwaters down to the reach end. Travel times are incorporated by offsetting the gains in appropriate reaches.

3. Natural flow is then allocated by priority. The allocation process begins with the oldest priority by subtracting the lesser of the right or the amount of the diversion from the natural flow at the end of its reach and all downstream reaches. This process is repeated successively in order of priority, regardless of location, resulting each time in a set of remaining natural flows (RNF) throughout the basin. When a zero RNF is computed, all natural flow in the basin above that point is allocated. When zero RNF occurs at the end reach (Milner), allocation is complete.

4. Diversions in excess of their allocated natural flow are diverting the excess from storage. If the diversion has no storage account or has used up its entitlement, it must rent additional storage water, or be reduced to its natural flow entitlement.

5. Accounting is run throughout the year to allow available natural flow to accrue to the correct reservoirs in accordance with their water rights. Storage is credited to a reservoir right if RNF is available to the reservoir priority in its reach, even if no water is stored there. This is done to avoid the accounting process from being a counter incentive to efficient management reservoirs as a group.

APPENDIX F: DETAILS PERTINENT TO EACH TRIBUTARY BASIN STUDY

UPPER HENRYS FORK BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the upper Henrys Fork basin utilizing the method previously described. A study performed by Whitehead (1978) will be the primary source of information on the hydrogeology of the basin. This report contains data on aquifer characteristics, depth to water, and streamflow reach gain and loss measurements. A field visit to the basin will provide information on estimates of the streambed characteristics of upper Henrys Fork and percentages of each ground-water irrigated crop. Due to the relatively small amount of ground-water development currently in the basin and the available data from previous studies, the time and cost to perform the proposed study are estimated to be only three and one-half man-months and $21,000, respectively.

FALLS RIVER/CONANT CREEK BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Falls River/Conant Creek basin utilizing the method previously described. Well driller's reports will provide the primary source of information on the aquifer characteristics. A field visit to the basin will provide information on depth to water estimates of the streambed characteristics of Falls River and Conant Creek, and percentages of each ground-water irrigated crop. Hydraulic conductivity of the streambed will be estimated from aquifer characteristics and compared with computed values for other tributary basins. Due to the relatively small amount of ground-water development currently in the basin, the time and cost to perform the proposed study are estimated to be only three man-months and $18,000, respectively.

TETON RIVER BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Teton River basin utilizing the method previously described. A study performed by Kilburn (1964) will be the primary source of information on the hydrogeology of the upper portion of the basin. This report contains data on aquifer characteristics and depth to water. Aquifer characteristics for the lower portion of the basin will be acquired from driller's reports. A field visit to the basin will provide information on depth to water in the lower portion, estimates of the streambed characteristics of Teton River, streamflow reach gain and loss measurements, and percentages of each ground-water irrigated crop. Due to the relatively large amount of ground-water development currently in the basin and the lack of available data, the time and cost to perform the proposed study are estimated to be six man-months and $36,000, respectively.

REXBURG BENCH

Surface water and ground water in the Rexburg Bench are <u>not</u> hydraulically connected, as is evident by Moody Creek (the principal drainage) being perched above the regional water table. As a result, the model created for this area will only simulate changes in underflow leaving the basin from ground-water withdrawal. The method that will be used is identical to what was previously described, except that there will be no surface water component included in the model.

Well driller's reports will provide the primary source of information on the aquifer characteristics. A field visit to the area will provide information on percentages of each ground-water irrigated crop. Due to the relatively large amount of ground-water development currently in the basin, the time and cost to perform the proposed study are estimated to be four man-months and $24,000, respectively.

SOUTH FORK OF THE SNAKE RIVER BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the South Fork of the Snake River basin utilizing the method previously described. Well driller's reports will provide the primary source of information on the aquifer characteristics. A field visit to the basin will provide information on estimates of the streambed characteristics of the South Fork of the Snake River, and percentages of each ground-water irrigated crop. Hydraulic conductivity of the streambed will be estimated from aquifer characteristics and compared with computed values for other tributary basins. Due to the relatively small amount of ground-water development currently in the basin, the time and cost to perform the proposed study are estimated to be only three man-months and $18,000, respectively.

WILLOW CREEK BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Willow Creek basin utilizing the method previously described. Well driller's reports will provide the primary source of information on the aquifer characteristics. A field visit to the basin will provide information on depth to water, estimates of the streambed characteristics of Willow Creek, and percentages of each ground-water irrigated crop. Hydraulic conductivity of the streambed will be estimated from aquifer characteristics and compared with computed values for other tributary basins. Due to the relatively small amount of ground-water development currently in the basin, the time and cost to perform the proposed study are estimated to be only three man-months and $18,000, respectively.

BLACKFOOT RIVER BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Blackfoot River basin utilizing the method previously described. Well driller's reports will provide the primary source of information on the aquifer characteristics. A field visit to the basin will provide information on depth to water, estimates of the streambed characteristics of Blackfoot River, and percentages of each ground-water irrigated crop. Hydraulic conductivity of the streambed will be estimated from aquifer characteristics and compared with computed values for other tributary basins. Due to the relatively small amount of ground-water development currently in the basin, the time and cost to perform the proposed study are estimated to be only three man-months and $18,000, respectively.

PORTNEUF RIVER BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Portneuf River basin utilizing the method previously described. A study performed by Norvitch and Larson (1970) will be the primary source of information on the hydrogeology of the basin. This report contains data on aquifer characteristics and depth to water. A field visit to the basin will provide information on estimates of the streambed characteristics of Portneuf River, streamflow reach gain and loss measurements, and percentages of each ground-water irrigated crop. Due to the relatively large amount of ground-water development currently in the basin and the lack of available data, the time and cost to perform the proposed study are estimated to be six man-months and $36,000, respectively.

BANNOCK CREEK BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Bannock Creek basin utilizing the method previously described. A study performed by Spinazola and Higgs (in review) will be the primary source of information on the hydrogeology of the basin. This report contains data on aquifer characteristics. A field visit to the basin will provide information on depth to water, estimates of the streambed characteristics of Bannock Creek, streamflow reach gain and loss measurements, and percentages of each ground-water irrigated crop. Due to the relatively large amount of ground-water development currently in the basin and the lack of available data, the time and cost to perform the proposed study are estimated to be four and one-half man-months and $27,000, respectively.

ROCKLAND BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Rockland basin utilizing the method previously described. A study performed by Williams and Young (1982) will be the primary source of information on the hydrogeology of the basin. This report contains data on aquifer characteristics, depth to water, and streamflow reach gain and loss measurements. A field visit to the basin will provide information on estimates of the streambed characteristics of Rock Creek and percentages of each ground-water irrigated crop. Due to the relatively small amount of ground-water development currently in the basin and the available data from previous studies, the time and cost to perform the proposed study are estimated to be only three and one-half man-months and $21,000, respectively.

RAFT RIVER BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Raft River basin utilizing the method previously described. Studies performed by Nace and others (1961) and Walker and others (1970) will be the primary sources of information on the hydrogeology of the basin. These reports contain data on aquifer characteristics and streamflow reach gain and loss measurements. A field visit to the basin will provide information on depth to water, estimates of the streambed characteristics of Raft River, and percentages of each ground-water irrigated crop. Due to the relatively large amount of ground-water development currently in the basin, the time and cost to perform the proposed study are estimated to be five and one-half man-months and $33,000, respectively.

OAKLEY FAN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Oakley Fan area utilizing the method previously described. A study performed by Young and Newton (1989) will be the primary source of information on the hydrogeology of the area. This study included model simulations of the stream-aquifer system. The aquifer boundaries and properties, and stream-aquifer parameters used in their calibrated model will be directly input into the model that is developed from this study. A field visit to the area will provide information on percentages of each ground-water irrigated crop. Due to the available data from the previous modeling study, the time and cost to perform the proposed study are estimated to be only four man-months and $24,000, respectively.

CAMAS/BEAVER CREEK BASINS

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Camas/Beaver Creek basins utilizing the method previously described. A study performed by Spinazola (1994) will be the primary source of information on the hydrogeology of the area. This study included model simulations of the stream-aquifer system in the lower portions of these basins. The aquifer boundaries and properties, and stream-aquifer parameters used in his calibrated model will be directly input into the model that is developed from this study. A field visit to the basins will provide information on depth to water, estimates of the streambed characteristics of Beaver and Camas Creeks, and percentages of each ground-water irrigated crop. Due to the available data from the previous modeling study, the time and cost to perform the proposed study are estimated to be only four man-months and $24,000, respectively.

MEDICINE LODGE CREEK BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Medicine Lodge Creek basin utilizing the method previously described. Well driller's reports will provide the primary source of information on the aquifer characteristics. A field visit to the basin will provide information on depth to water estimates of the streambed characteristics of Medicine Lodge Creek, streamflow reach gain and loss measurements, and percentages of each ground-water irrigated crop. Due to the relatively large amount of ground-water development currently in the basin and the lack of available data, the time and cost to perform the proposed study are estimated to be four and one-half man-months and $27,000, respectively.

BIRCH CREEK BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Birch Creek basin utilizing the method previously described. Well driller's reports will provide the primary source of information on the aquifer characteristics. A field visit to the basin will provide information on depth to water estimates of the streambed characteristics of Birch Creek and percentages of each ground-water irrigated crop. Hydraulic conductivity of the streambed will be estimated from aquifer characteristics and compared with computed values for other tributary basins. Due to the relatively small amount of ground-water development currently in the basin, the time and cost to perform the proposed study are estimated to be only three man-months and $18,000, respectively.

LITTLE LOST RIVER BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Little Lost River basin utilizing the method previously described. A study performed by Clebsch and others (1974) will be the primary source of information on the hydrogeology of the basin. This report contains data on aquifer characteristics and depth to water. A field visit to the basin will provide information on estimates of the streambed characteristics of Little Lost River and percentages of each ground-water irrigated crop. Hydraulic conductivity of the streambed will be estimated from aquifer characteristics and compared with computed values for other tributary basins. Due to the relatively small amount of ground-water development currently in the basin and the available data from previous studies, the time and cost to perform the proposed study are estimated to be only three and one-half man-months and $21,000, respectively.

BIG LOST RIVER BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Big Lost River basin utilizing the method previously described. Studies performed by Crosthwaite and others (1970) and Goodell and others (in review) will be the primary sources of information on the hydrogeology of the basin. Both reports contain data on aquifer characteristics, depth to water, and streamflow reach gain and loss measurements. The second study included model simulations of the stream-aquifer system in the lower portion of the basin. The aquifer boundaries and properties, and stream-aquifer parameters used in their calibrated model will be directly input into the model that is developed from this study. A field visit to the basin will provide information on estimates of the streambed characteristics of Big Lost River and percentages of each ground-water irrigated crop. Due to the available data from previous studies, the time and cost to perform the proposed study are estimated to be only four and one-half man-months and $27,000, respectively.

LITTLE WOOD RIVER BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Little Wood River basin utilizing the method previously described. Well driller's reports will provide the primary source of information on the aquifer characteristics. A field visit to the basin will provide information on depth to water estimates of the streambed characteristics of Little Wood River and percentages of each ground-water irrigated crop. Hydraulic conductivity of the streambed will be estimated from aquifer characteristics and compared with computed values for other tributary basins. Due to the relatively small amount of ground-water development currently in the basin, the time and cost to perform the proposed study are estimated to be only three and one-half man-months and $21,000, respectively.

BIG WOOD RIVER BASIN

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Big Wood River basin utilizing the method previously described. A study in progress by Brockway and others will be the primary source of information on the hydrogeology of the area. This study will include model simulations of the stream-aquifer system. The aquifer boundaries and properties, and stream-aquifer parameters used in their calibrated model will be directly input into the model that is developed from this study. A field visit to the basin will provide information on percentages of each ground-water irrigated crop. Due to the available data from the current modeling study, the time and cost to perform the proposed study are estimated to be only three and one-half man-months and $21,000, respectively.

CAMAS PRAIRIE

A stream-aquifer model will be created that will simulate the relationship between surface water and ground water in the Camas Prairie utilizing the method previously described. A study performed by Young (1978) will be the primary source of information on the hydrogeology of the basin. This report contains data on aquifer characteristics, depth to water, and streamflow reach gain and loss measurements. A field visit to the basin will provide information on estimates of the streambed characteristics of Camas Creek and percentages of each ground-water irrigated crop. Due to the relatively small amount of ground-water development currently in the basin and the available data from previous studies, the time and cost to perform the proposed study are estimated to be only three and one-half man-months and $21,000, respectively.

APPENDIX F LIST OF REFERENCES

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